Complete Listing of Claims

1.   A collision warning system mounted on an observer aircraft for passively detecting and tracking nearby target aircraft equipped with a transponder responsive to interrogation signals from a rotating radar source, comprising:

   direction finding antenna means for receiving signals from the radar source and the transponder-equipped aircraft and measuring the bearing of said signals;

   means for determining the position of the observer aircraft;

   means for determining the position of the radar source;

   means for determining the total trip distance from the radar source to the target aircraft to the observer aircraft;

   means for determining the position of the target aircraft from the range to the radar source, the total trip distance, and the bearing of the target aircraft relative to the observer aircraft measured by said direction finding antenna means; and

   means for warning the pilot of the observer aircraft of the presence of the target aircraft for collision avoidance.

2.   The collision warning system according to claim 1, wherein said direction finding antenna means and said means for determining positional information of the observer aircraft are included in a external device mounted on the observer aircraft.

3.   The collision warning system according to claim 2, wherein said means for determining positional information of the observer aircraft includes means for receiving satellite navigation signals from the GPS or Galileo navigation systems, or by using a non-satellite navigation system.

4.   The collision warning system according to claim 2, further comprising processing means, such as portable computer connected to the external device for receiving data from the external device, wherein the computer, executes a control program for

processing the data for output to said warning means to alert the pilot of the presence of the target aircraft for collision avoidance.

5. The collision warning system according to claim 1, further comprising a display accessible and convenient to the pilot of the observer aircraft while piloting the aircraft.

6. The collision warning system according to claim 1, wherein said warning means includes audio means for alerting the pilot of the presence of the target aircraft for avoiding collisions.

7. The collision warning system according to claim 1, wherein said direction finding antenna means is a multi-element direction finding antenna capable of simultaneously receiving signals from at least two target aircraft and the rotating radar source using a signal receiving method such as ESPRIT, MUSIC, or WSF.

8. A method of collision avoidance by determining the position, relative to an observer aircraft, of at least one target aircraft equipped with a transponder transmitting reply signals in response to interrogation signals from a rotating radar source comprising the steps of:

a) determining the position of the observer aircraft;

b) determining the position and range of the radar source relative to the observer aircraft by measuring the bearing of interrogation signals with a direction finding antenna;

c) determining the bearing of the target aircraft relative to the observer aircraft by measuring reply signals with a direction finding antenna;

d) determining the position of the target aircraft with a computer executing software for processing data comprising the determined positions of the observer aircraft and radar source, and the measured bearing of the target aircraft; and

e) presenting the position of the target aircraft relative to the observer aircraft to the pilot of the observer aircraft to assist in collision avoidance.

9. The method according to claim 8, wherein the position of the observer aircraft is determined by using a receiver capable of receiving satellite-based navigation signals such as from the GPS or Galileo navigation systems, or by using a non-satellite navigation system.

10. The method according to claim 9, wherein the GPS receiver and the direction finding antenna are included in a device mounted externally on the observer aircraft, whereby the computer is linked to the device and processes data received from said device.

11. The method according to claim 10, wherein externally mounted device further includes a tuner for receiving the interrogations and transponder replies, a A/D converter, and a DSP for processing the received signals.

12. The method according to claim 8, wherein step d) further comprises:
    calculating the distance of the cumulative propagation trip distance of the interrogation signal from the radar source to the target aircraft and the reply signal from the target aircraft to the observer aircraft; and
    determining the position of the target aircraft, relative to the observer aircraft, based on the bearing of the target aircraft, the distance of cumulative signal propagation, and the range to the radar source.

13. The method according to claim 8, wherein step e) includes presenting the position of the target aircraft relative to the observer aircraft on a display that is conveniently accessible to the pilot of the observer aircraft while piloting the aircraft such as e.g. on the cockpit instrument panel or on a display attached to the pilot's leg.

14. The method according to claim 8, wherein the presenting step includes audio warnings that alert the pilot of the presence or location of the target aircraft to assist in collision avoidance.

15. The method according to claim 8, wherein the position of the target aircraft are tracked by storing in a memory of the computer the relative positions of the target aircraft over predetermined period of time.

16. The method according to claim 8, wherein the direction finding antenna uses a signal receiving method such as MUSIC, ESPRIT, or WSF to determine the bearing of said signals.

17. The method according to claim 16, wherein the direction finding antenna uses the MUSIC signal receiving method that is operative in the azimuth and elevation directions.

18. The method according to claim 8, wherein said direction finding antenna means is a multi-element direction finding antenna simultaneously receiving signals from at least two target aircraft and the rotating radar source using a signal receiving method such as ESPRIT, MUSIC, or WSF.

19. The method according to claim 8, wherein the angular rotational speed of the rotating radar source is estimated by factoring in the motion of the observer aircraft relative to the rotation of the radar source by computing the change in the angle $\Delta\theta$ at which the interrogation signal is received on successive rotations of the radar source.

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20. The method according to claim 8, whereby the position of transponder-carrying objects such as automobiles and land/seafaring animals can determined.

21. A computer program product for displaying the relative position of a target aircraft to an observer aircraft comprising:

a computer readable storage medium having a computer readable program code means embedded in said medium, the computer readable program code means comprising:

a) a first computer instruction means for receiving signals data from a direction finding antenna, wherein the signals include interrogation signals from a rotating radar source and reply signals responsive to interrogations signals from a transponder equipped target aircraft;

b) a second computer instruction means for receiving satellite navigation signals data for determining the position of the observer aircraft;

c) a third computer instruction means for determining the position of the target aircraft from said data;

d) a fourth computer instruction means for displaying the target aircraft relative to the observer aircraft at a periodically updated position.

22. (Currently Amended) The [method] computer program product according to claim [18] 21, wherein the computer readable storage medium containing the computer readable program code is operable for controlling a portable computer such as a laptop computer or PDA to display the relative position of a target aircraft to an observer aircraft.